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Abstracts for Winning Proposals

Proposal Number	ATIP-99-0069
Title	Laser Sounder Technology for Atmospheric CO2 Measurements from Space
PI	Abshire, James

Abstract

We propose to develop and demonstrate the critical laser technology which will enable atmospheric CO2 measurements from orbit. These will be used in a new orbital laser sounding approach for measuring the spatially resolved column abundance of CO2 in the Earth's atmosphere. Such measurements from an orbital sounder can be used to generate, for the first time, global maps of the relative tropospheric column abundance of this important greenhouse gas every two weeks. Our technique measures the strong laser echoes reflected from the Earth□s land and water surfaces as the two lasers are rapidly tuned on and off the selected atmospheric CO2 and O2 absorption lines. Our approach measures the relative abundance of CO2 at the dawn and dusk times needed to address the primary science questions on surface-atmosphere carbon exchange. It permits the tropospheric column CO2 to be normalized to O2 measurements with the needed 0.5 ppm accuracy. Our laser technique uses very narrow (MHz) linewidth lasers and has much higher spectral resolution, and precision than is possible with passive spectrometers. It also can be used at the dawn-dusk periods, which show maximum response from the diurnal CO2 cycle.

For this NRA, we will develop and demonstrate laboratory versions of the critical laser and receiver technology and conduct tradeoff assessments. We will demonstrate bench top versions of our transmitters and receivers and our CO2 and O2 measurement capability and at the breadboard level. For the CO2 measurements, we will use a tunable single frequency semiconductor laser operating in the CO2 overtone band near 1572 nm. It will be locked to a CO2 line in an absorption cell and followed by an array of erbium-doped fiber optical-amplifiers. These components are widely used in the fiber telecommunications industry. However, they require further development for spectroscopic measurements of CO2 and for power scaling. We will use a similar approach for O2 measurements in the O2 A-band near 761 nm, but follow the seed laser by semiconductor laser amplifiers. We will also develop and demonstrate the photon counting detectors and narrow band filters and etalons needed for the receiver at both wavelengths in a laboratory breadboard.

Our technology is presently at TRL level 2.5, and through this work we will exit at TRL level 5. Our proposed work is very feasible, since it leverages our concept definition work supported by Goddard Director□s Discretionary funding, its transmitter technology from the 1570 nm diode and fiber lasers being developed in telecommunications industry, and 760 nm diode lasers being developed under a NASA-Goddard Phase-2 SBIR. The receiver work leverages the development of the GLAS optical receiver for the NASA□s ESE ICESAT mission, industry and DOD development of long wavelength photomultipliers, and our Goddard (Krainak) Cross Enterprise laser technology RTOP. Our science and technology heritage includes successful development and operation of the MOLA lidar on Mars Global Surveyor, the ongoing development of the GLAS instrument, and atmospheric carbon and chemistry science investigations. NASA Goddard□s Earth Science□s Directorate has a very strong interests in laser remote sensing and the Earth□s carbon cycle.

Proposal Number	ATIP-99-0084
Title	WATER VAPOR DIAL TRANSMITTER AT 0.94 Micrometers
PI	Barnes, Norman

Abstract

An efficient laser transmitter for measuring water vapor using the DIAL technique around 0.94 mm is proposed. Water vapor is very high on the Earth Science Enterprise measurements needs list because it contributes to many effects including weather and global warming. Because the water vapor absorption lines are considerably stronger around 0.94 mm than the currently used 0.82 mm lines, more accurate measurements in the upper troposphere and lower stratosphere are possible. Langley demonstrated a novel approach to a 0.94 mm DIAL transmitter using a Langley developed laser material, Nd:GYAG, and an improved laser design. A flashlamp pumped laser at NASA Langley provided an order of magnitude improvement over the best comparable published data. The proposed laser diode pumped laser utilizes a better laser geometry which improves efficiency and permits conductive cooling therefore increasing reliability and improving lifetime. These improvements promote subsequent space borne deployment. Projections, based on existing date, indicate the efficiency for this system will be over twice the efficiency of a comparable Ti:Al2O3 system. In addition, a frequency tripled version of this laser transmitter, operating in the ultraviolet is a good candidate for other remote sensing applications needed by the Earth Science Enterprise.

Proposal Number	ATIP-99-0032
Title	Efficient, Compact, Conduction Cooled Laser Diode-Pumped Yb:YAG Laser for Atmospheric Composition and Ozone Measurements
PI	Byer, Robert

Abstract

Global measurements of ozone, water vapor, and trace constituents require UV laser transmitter technology at 0.5 J per pulse, 10 Hz repetition rate, and a near diffraction limited spatial profile. Further, the laser transmitter must meet space platform requirements of high efficiency, compact size, low weight and reliability.

We propose to develop, in collaboration with NASA Langley, a laser-diode-pumped, high pulse energy Yb:YAG slab laser. The source, called a ""laser engine"", is based on two years of basic research experience during which we demonstrated the efficiency and reliability of fiber-coupled, laser-diode edge-pumped Nd:YAG slab lasers. This conduction cooled, multimode Nd:YAG laser operated at 127 W for 300 W of laser diode input power at 55% slope efficiency and 42% optical-to-optical efficiency, which is the highest efficiency Nd:YAG slab laser reported to date.

We propose to extend this innovative edge-pumped slab design to Yb:YAG for increased energy storage. The proposed program is initiated at technical readiness level (TRL) 3 and progresses in three years to TRL 4 with proposed options to extend to TRL 5. The proposed program is staged over the three year period to remain cost effective while maximizing analytical and experimental support for energy scaling in the UV to the 0.5 J per pulse level at 10 Hz repetition rate. Nonlinear frequency conversion studies will be conducted in collaboration with NASA Langley Research Center.

Proposal Number	ATIP-99-0101
Title	Development of a Low Power, Miniaturized Module for the Next Generation Microwave Radiometers
PI	Doiron, Terence

Abstract

The goal of this investigation is to develop a low power, miniaturized receiver module in support of the next generation of microwave radiometers. Observations of key hydrological parameters at the spatial and temporal scales required in the post-2002 era face significant technological challenges. These measurements are based on relatively low frequency thermal microwave emission (at 1.4 GHz for soil moisture and salinity, 10 GHz and up for precipitation, and 19 and 37 GHz for snow). The long wavelengths at these frequencies coupled with the high spatial and radiometric resolutions required by the various global hydrology missions necessitate the use of very large apertures (e.g., >20 m) and highly integrated stable RF electronics on orbit.

Synthetic Thinned Array Radiometry (STAR) is the most promising technology to enable very large non-rotating apertures in space. STAR instruments are composed of arrays of small antenna/receiving elements that are arranged so that the collecting area is smaller than an equivalent real aperture system [1,2,3], allowing very high packing densities for launch. A 20-meter aperture at L-band, for example, will require >1000 of these receiving elements.

The current state-of-technology, when projected to future missions, results in unacceptably high power consumption for the instruments. It is clear that development in this area needs to take place before large STAR missions are feasible in the 2005-2007 timeframe. The goals of this development are to design a receiver module with a power consumption of # 0.25 W per frequency per polarization (i.e., ~1 W power per module) and a mass of ~0.2 kg (~0.8 kg per module), with a noise temperature of # 250 K, which directly addresses the implementation of almost all of the future hydrology missions. These modules would be the building block for large deployable 2-D STAR instruments.

This effort will be performed by the Microwave Instrument Technology Branch (MITB) at the Goddard Space Flight Center (GSFC) in partnership with the Sensors Research Branch at Langley Research Center, and the University of Massachusetts.

Proposal Number	ATIP-99-0022
Title	High Efficiency Remote Sensing Laser Technology
PI	Fields, Renny

Abstract

The Aerospace Corporation is proposing the development of high-brightness laser-diode pump-modules to greatly increase the electrical efficiency of solid-state lasers used for space-based remote sensing. Of the 111 Earth Science Enterprise Capability/Needs assessments, 18 require lasers that would benefit from the technology proposed here. To date, all flight lasers for altimetry or cloud LIDAR have been built using a transverse pumping geometry. For this configuration, the highest reported electrical efficiency (electrical-in vs. optical out) is 6 %, which has been observed for the ICESAT mission in its pre-flight stage. The costs of many laser-based experiments have become prohibitive due to the laser□s size, weight and power requirements. If smaller more electrically efficient lasers were implemented, more capable instruments could be flown or the cost reduced for the most basic missions. To date, no contractors have proposed longitudinally pumped flight lasers, since laser-diode pump sources exhibiting the appropriate brightness, power level and reliability are not available. Several years ago, the Aerospace Corporation patented and demonstrated a novel lens and diode bar-array that resulted in a multi-watt longitudinally pumped solid-state 1-micron laser operating at 19% electrical efficiency. The Coherent Semiconductor Group, a commercial diode laser producer, has recently demonstrated high reliability CW diode arrays compatible with Aerospace□s micro-lens arrays. The combination of the lens arrays with pulsed versions of the Coherent diode bars will enable a Q-switched 1-micron Nd:YAG laser to operate with an efficiency in the range of 15 to 25%. Both Aerospace and Coherent have come to an agreement that two-dimensional pump array modules can be developed to provide a collimated output of 600 W/cm2 at 2% duty factor. Aerospace is proposing to develop these modules and demonstrate a longitudinally pumped 1-micron Nd:YAG proto-flight laser applicable to cloud/aerosol and altimetry measurements. Similar pump devices could be developed at other wavelengths to pump lasers applicable to water vapor, Ozone, and coherent wind measurements.

Proposal Number	ATIP-99-0047
Title	Synthetic Aperture (SAR) Radar On-Board Azimuth Pre-Filter Processor
PI	Gudim, MiMi

Abstract

Synthetic Aperture Radar (SAR) missions planned for the near futureare pushing downlink data bandwidths to prohibitive levels. We proposea solution to significantly reduce the bandwidth required to return a givenscience data set. We propose to develop an ASIC-technology-basedsignal processing unit to perform part of the SAR signal processing onboard, which when included in the design of future SAR missions such asEOS-8, EX-6 and EX-7 will reduce the required downlink data bandwidth bya factor of four (4) or greater. Successful reduction in data rateof this magnitude will enable direct transmission of data from the spacecraftto low-cost, compact ground receiving stations, and provide faster turn-aroundtime of science data. The proposed unit will perform azimuth pre-filteringaboard a SAR instrument. The design will be configurable to provide applicabilityfor multiple future missions. Given the intense computational powerand speed required for this function, the unit will be developed to targetthe space-qualified, fastest and highest density Field Programmable GateArray to be available from the industry in early 2000, the Xilinx VirtexXQVR1000.

The success of the proposed unit and its significant benefits for futureSAR missions depend upon close collaboration between highly experiencedradar scientists (e.g. geologists, oceanographers, hydrologist, ecologists)and radar system engineers committed to and embedded in the current andfuture SAR systems, and technologists that have experience and expertisein signal processing algorithms and their implementation in the state-of-the-arttechnologies. The proposing team has this necessary combination ofmembers, working together with common enthusiasm to improve future SARmission capability by combining the expertise mix.

This team will deliver (at an estimated cost of $292k (1st year), $297.9k(2nd year), and $27.2k (3rd year)):

" a SAR signal processing scheme to reduce required downlinkdata bandwidth by a factor of four or greater for future Earth Science missions, e.g.EOS-8, EX-6 and EX-7

" a compact, low-mass, flight-qualifiable brass-board unit withdemonstrated capability to perform the on-board signal processing scheme

" a brass-board unit at TRL level 5, demonstrated in the laboratorywith actual SAR input data

" a final report documenting the system design and the signalprocessing unit

" a submission to a refereed journal documenting this break-throughdesign.

Proposal Number	ATIP-99-0054
Title	High Efficiency, Double-Pulsed, High Beam Quality, Nd Laser for Global Ozone
PI	Hovis, Floyd

Abstract

The Earth Science Enterprise Capability Matrix identifies space-based ozone differential absorption lidar (DIAL) as a high priority instrument in need of technology development. This matrix element calls for the development of a space-based UV laser transmitter as a critical step in enabling global earth observations of aerosols and ozone at resolutions greater than current satellite instrument capabilities.

This proposal, in combination with others described below, offers a development strategy for creating robust laser instrumentation capable of ozone DIAL missions for New Millennium Program (NMP) and EX-1 during the next 10 years. Our approach advocates making maximum use of existing, space-qualified optical components to reduce risk, cost, and development time. Our laser design has been down selected in both NASA and industry system studies and represents a sizeable head start over alternate approaches.

A critical component of the ozone DIAL system is a space-qualified 1?m pump source that provides single frequency, high energy, and high beam quality pulses in a dual-pulse format. These pump requirements maximize conversion efficiency and minimize the risk of damage for the nonlinear processes used in the UV laser.

Although 1?m laboratory lasers can approach the desired output, the technologies on which these lasers are based are not compatible with the requirement to operate in space. Common shortcomings include the inability to survive the vibrational environment of a launch, intolerance of wide thermal variations, and the requirement to use liquid-based cooling for heat removal. Fibertek is a leader in the development of robust, diode-pumped solid state lasers for space and military applications. A number of our Nd:YAG laser systems have been formally qualified and used in military systems. We are also in the process of building and qualifying two systems for long-term space missions. These two systems are the laser transmitters for use in the ESSP sponsored Vegetation Canopy Lidar (VCL) and PICASSO-CENA missions.

The primary objective of this proposal is to demonstrate 1 ?m laser technology that is space-qualifiable and can achieve the following performance characteristics:

1. >1 J single frequency pulses in a dual-pulse format .

2. True wall plug efficiencies of 10% electrical-to-optical.

3. Reduced package size and weight.

These state-of-the-art requirements could be achieved with ATI funding of the proposed development.

Proposal Number	ATIP-99-0100
Title	Development of a Monolithic GaAs Hyperspectral Infrared QWIP Imaging System
PI	Jhabvala, Murzy

Abstract

The goals of this project are to: 1) design, fabricate and hybridize to a readout integrated circuit (ROIC) a completely monolithic 512 x 640 element, four band Gallium Arsenide (GaAs) Quantum Well Infrared Photoconductor (QWIP) array, 2) utilize a state-of-the-art cryocooler for mechanical cooling to 43K, 3) build a complete pushbroom camera system including all drive, data acquisition and display electronics, 4) design and produce the front end optics, 5) design and specify a drop-in linear variable etalon (LVE) hyperspectral filter element, and finally 6) integrate all subassemblies into a compact Hyperspectral QWIP Imaging (HQI) system.The QWIP array will be fabricated by a graded Molecular Beam Epitaxial (MBE) growth process that will yield four distinct spectral response bands across the array: Band 1 -- 3 to 5_m; Band 2 -- 8.5 to 10_m; Band 3 -- 10 to 12_m; Band 4 -- 14 to 15.4_m. The pixel size will be 23 x 23_m. Each band will occupy 128 elements in the along-track direction and 640 elements in the across-track direction. The LVE will be constructed to yield hyperspectral filtering in the along-track direction of each of the four bands with a resolving power of 100 or greater. This instrument represents a major increase in QWIP technological complexity and

therefore, requires substantial expertise and involvement from two additional premier QWIP technology groups: the Infrared Focal Plane Array Technology Group of the Jet Propulsion Laboratory (JPL) and the Infrared Materials and Devices Branch of the Army Research Laboratory (ARL), in addition to the Goddard Space Flight Center (GSFC).The hyperspectral measurements we will enable and demonstrate in the 3 to 15.4 micron region will allow remote sounding of numerous geophysical quantities such as cloud (height and fraction, emissivity, particle size and phase), surface (soil and vegetation type, temperature, emissivity, pollutants), and atmospheric (temperature and composition) parameters. In addition, rapidly varying phenomena such as fire (temperature and extent) and volcanic eruptions (SO2, aerosols, temperature) can be observed. Powerful spaceborne multispectral instruments such as MODIS and AVHRR currently have thermal capability that will address some of these questions, and the airborne hyperspectral AVIRIS has shown the utility of hyperspectral measurements in the visible/short-wave IR region. However, the need for smaller, lighter and lower cost imaging radiometers is now apparent, particularly in missions that combine different types of remote sensing instruments. Instruments requiring different detectors for different channels impose a severe cost and complexity burden on the focal plane, and the specific detector can further drive the optical design to larger and more costly elements to obtain sufficient signal. The key to developing smaller, lighter and less costly imagers is the development of a more integrated, diverse focal plane. The proposed multiband, hyperspectral GaAs QWIP is a major step in achieving these goals.

Proposal Number	ATIP-99-0105
Title	A Compact, Highly-Efficient, and Rugged All Solid-State UV Source Based on Fiber Lasers for UV-DIAL
PI	Kang, Jin

Abstract

We proposed to develop a highly efficient (> 10% wall-plug efficiency),compact, light, rugged, and tunable UV source based on high power Q-switchedYb-doped and Er/Yb-doped fiber lasers. The proposed UV source isbased on nonlinear frequency mixing of a frequency doubled Yb-fiber laserwith a frequency doubled Er/Yb-fiber laser to generate desired UV wavelengths. This configuration is more efficient then flashlamp-pumped or diode-pumpedsolid state laser configurations and much more stable and longer lastingthan the use of wide bandgap diode lasers. Furthermore, the use offiber lasers and fiber based components eliminates need for alignment andmakes the whole system rugged, compact, and light. We will use fiberpigtailed periodically poled LiNbO3 to frequency double the fiber lasers. Use of waveguide increases the nonlinear frequency conversion efficiencyand we fully expect conversion efficiency in excess of 80 %. By tuningthe wavelength of either Yb- or Er/Yb- doped fiber lasers one can obtainUV lights with a wavelength anywhere between 307nm to 324 nm by frequencymixing two lasers using a standard nonlinear crystal such as LBO. To minimize the development time and the risk, we propose to use a commerciallyavailable Yb-fiber laser and a fiber output diode laser to develop thesource. These commercially available lasers require minimum modificationsfor the projects and can be easily packaged.

Proposal Number	ATIP-99-0003
Title	Small and Smart Sensor for Atmospheric Terahertz Limb Sounding
PI	Karasik, Boris

Abstract

Recent research at JPL in superconducting bolometer mixer technology enables a new generation of ""frequency-programmable"", sensitive heterodyne instruments in the submillimeter or terahertz region (0.5-3 THz or 100-600 mm). This new technology is based on a high-sensitivity, broadband YBa2Cu3O7-_ (YBCO) superconducting hot electron bolometer mixer. This mixer would replace the Schottky diode mixers currently used in atmospheric remote-sensing instruments. The YBCO mixer noise temperature is expected to be 2-to-5 times lower than a Schottky mixer. This would allow for about 4 to 25 times as much data to be collected with the same signal to noise. Thus daily maps of important chemical species could be collected, where now only monthly averages are possible. This mixer can also be easily integrated into a 2-dimensional array for mapping and imaging applications. This would lead to much more cost effective missions with significantly increased science return. In addition, the YBCO mixer requires 100-times less local oscillator (LO) power than a Schottky mixer, which means that a frequency-agile, compact, solid-state LO source can be used, rather than the bulky, fixed-frequency gas lasers used as LO□s for THz Schottky mixers. This provides for a programmable sensor that would significantly reduce the cost and risk of a space-borne instrument. The frequencies and molecules to be studied no longer will need to be ""lock-in"" years before flight. This mixer technology is focussed on the EOS-7 atmospheric chemistry mission. The corresponding Terahertz Limb Sounding (TLS) instrument would study and monitor a variety of important stratospheric molecules in the terahertz spectral region.

Proposal Number	ATIP-99-0093
Title	Controlled-Correlation Subsystem for On-Board receiver Calibration of Synthetic Thinned Array Radiometers (STAR) and Fully-Polarimetric (FP) Microwave Radiometers
PI	Kim, Edward

Abstract

Two types of microwave radiometry---synthetic thinned array radiometry(STAR) and fully-polarimetric (FP) radiometry---have received increasingattention during the last several years. STAR radiometers offer atechnological solution to achieving high spatial resolution imaging fromorbit without requiring a filled aperture or a moving antenna, and FP radiometersmeasure extra polarization state information upon which entirely new ormore robust geophysical retrieval algorithms can be based. Six ofthe instrument concepts for the post-2002 earth science notional missionsare based on one of these two technologies.

Radiometer configurations used for both STAR and FP instruments shareone fundamental feature which distinguishes them from more "standard" radiometers,namely, they measure correlations between pairs of microwave signals. The resultant increase in instrument complexity creates a variety of additionaltechnological requirements including tight matching and stability of theradiometer receivers themselves, as well as a more complex yet robust in-flightcalibration subsystem. Calibration is a critical aspect of any instrumentdesign and operation. However, it is often considered to be of secondaryimportance to the design of the instrument itself. As instrumentcomplexity increases this approach becomes more risky, potentially increasingthe chances of finding problems late in the development cycle and increasingcost. The complex nature of correlation radiometer calibration, coupledwith the inherent similarities between STAR and FP instruments, suggestssignificant leverage in addressing both problems together. This proposalseeks to develop a compact low-power subsystem for in-flight STAR and FPreceiver calibration including a signal source with precisely generatedcorrelation properties, along with a correlation receiver testbed to providerealistic test conditions and to guide optimization. STAR instrumentshave an additional requirement of needing a means of distributing a calibrationsignal to widely separated receivers. This proposal also seeks todevelop a compatible low-power fiber-optic based distribution link.

Proposal Number	ATIP-99-0066
Title	Diode Laser Stabilization for Optical Metrology: an Optical Atomic Clock in Support of Time-Varying Gravity-Mapping Missions
PI	Klipstein, William

Abstract

The output of this task will be demonstration of a stabilized diode laser system capable of supporting ESE□s post-2002 Time-Dependent-Gravity-Field Mapping Mission, EX-5. EX-5, planned for flight in 2006, will use interferometry between two low-Earth-orbit satellites to resolve mass distributions at the unprecedented scale of ocean eddies to provide detailed information on ocean circulation, ground or surface water storage, tectonic motion, and post-glacial rebound. This proposal promises the mission-critical technology of laser-stabilization performance in the form an optical atomic clock, delivering 100 mW of optical power at 852 nanometers, with a fractional frequency stability of 10 -13 from 1 ms to 1000 seconds. The laser will be stabilized in short times to a high-finesse Ultra-Low Expansion (ULE) cavity and at long times to a cesium atomic absorption line using acousto-optic and electro-optic modulators. Diode lasers provide high reliability and run at higher electrical efficiency than any other laser source and are thus ideal for flight missions. The absolute frequency reference provided by the cesium atoms will greatly simplify operations, reducing mission cost and increasing reliability.

Proposal Number	ATIP-99-0051
Title	Quantum Interface Gravity Gradiometer for 3-D Sub-Surface Mapping
PI	Maleki, Lute

Abstract

We propose a task for the development of an ultra-sensitive gravitygradiometer with the potential for producing detailed sub-surface mappingof the solid and fluid Earth. This instrument is based on the utilizationof atom interferometry for the realization of a gradiometer which usesatoms as the proof mass. The capability realized with this techniquewill open a new era for the study of various models of the solid and fluidEarth, and for the investigation of temporal changes and dynamic processes. Based on the results of this task a space instrument can be developed withthe desired features of long term stability, high absolute accuracy, ina robust package which can operate over the period of several years withoutthe need for cryogenic cooling.

Proposal Number	ATIP-99-0052
Title	Advanced Optical Heterodyne Receiver Development for Coherent Doppler Wind Lidar
PI	Mansour, Kamjou

Abstract

This proposal will involve advanced heterodyne receiver development incorporating novel semiconductor laser frequency-agile local oscillator (FALO) technology with direct application to coherent lidar remote sensing of atmospheric winds from Earth orbit, addressing the Instrument Option stipulated in Record 66 of the ESE Capability & Needs Matrix. Global-scale measurement of tropospheric winds offers the potential for dramatic improvements in weather forecasting skill and the elucidation of dynamical processes down to the mesoscale. Recognizing the importance of this measurement capability, the OP-2 mission has been baselined as a testbed for Doppler lidar technology to address the significant risks which must be retired prior to operational deployment as part of the planned NPOESS Earth-orbiting suite. According to the definitions contained in the NRA, this proposal constitutes a Class 2 activity.

Proposal Number	ATIP-99-0063
Title	Wide Field of View Adaptive Optical System for Lightweight Deployable Telescope Technologies
PI	McComas, Brian

Abstract

Ball Aerospace proposes an innovative technology for use in Advanced Technologies Initiatives Program (ATIP) for a light-weight deployed large aperture telescope. The proposed technology provides solutions to many implementation problems of such a telescope, including base motion disturbance rejection, optimized figure control of the primary mirror over the entire field of view required to cover the earth, relaxation of the pointing requirements of the spacecraft, and removal of the requirement for settling time after re-pointing.

The approach has already been developed and modeled to TRL 3 for an adaptive and active optical system that will allow high-resolution imagery over a large field of view. Using this technology, new adaptive optical systems for Earth observing will be able to produce high quality imagery over a large field of view. Further, Ball Aerospace has an array of existing and planned facilities that will be used to prove the concept.

The Ball Aerospace concept uses a combination of novel actuation of the primary mirror, along with a steering mirror, and an adaptive optic to achieve optimized image quality. This breakthrough allows the active and adaptive optical system to produce high-resolution well-corrected imagery across the entire field of view with little or no spacecraft slewing. Further, this solution provides rejection of base motion disturbance and dramatically shortens the settling time during which observations cannot be made. In addition, since pointing is made with a tiny mirror, repointing does not disturb the space structure. Finally, this solution will allow for quality imaging even if the spacecraft pointing drifts. This wide field-of-view technique is independent of wavefront sensor choice.

Proposal Number	ATIP-99-0060
Title	Optical Cryocooler Development
PI	Mord, Allan

Abstract

Optical refrigeration by fluorescence is a new and unique approach to cryocoolers, unrelated to the current state-of the-art such as the Stirling cryocooler. The uniqueness of this invention is that it has the potential to provide solid state cooling to liquid nitrogen temperatures, well below 180 K, the approximate limit of thermoelectric coolers. The advantages to the user of this technology are a cooled detector package that is tightly integrated, compact, and light, with very long life (no moving parts), zero vibration, zero electromagnetic interference (EMI), and lower cost.

Ball proposes an effort to advance optical cryocooling from a Technology Readiness Level of 3.1, where it currently stands, to a TRL of 4.1 in the first year. In the two subsequent years Ball proposes to move optical cryocooling to a TRL of 5, in which a complete breadboard system would be tested in a flight-like environment.

A $272,776 program is proposed for the first year, which includes testing of optical cooling elements, and operation of cooling elements in breadboard cryocoolers. A $272,712 and $273,567 program is proposed for the second and third years, which will include the design of a flight-like optical feed system and the development of a flight-like pump laser.

Proposal Number	ATIP-99-0057
Title	Multi-Spectral Staring CMOS Focal-Plane Array for Oceanographic Imaging Applications
PI	Pain, Bedabrata

Abstract

Research in Oceanography and Meteorology require high-resolution, high-sensitivity measurements in the Visible (Vis) and Near Infrared (NIR) part of the spectrum. These include ocean color studies and coastal imaging. We propose to develop an advanced, low-cost, compact, high-resolution, Vis/NIR staring multi-spectral digital focal-plane array (FPA) based on demonstrated CMOS Active Pixel Sensor (APS) and Surface-Plasmon-Tunable-Filter (SPTF) technologies. The proposed FPA will enable new scientific measurements by increasing the spatial resolution of the FPA, by reducing optical scatter and electronic cross-talk, by achieving high signal-to-noise ratio even for high-contrast scenes, and by allowing the user to choose a set of spectral bands in real-time, instead of using pre-determined filter-sets. It will also lead to significant reduction of risk, cost and instrument development time due to extensive on-focal-plane integration. The instrument implemented with this FPA will be an order of magnitude smaller in size, weight, and power.

The instrument component will also find use in atmospheric chemistry, cloud studies, aerosol studies, studies relating to vegetation recovery, volcanic ash characteristics, flood characterization, and land-cover usage and changes. The estimated cost is $860.1 K for 3 years. The component technologies will enter at approximately TRL 3 and exit at approximately TRL 5.

Proposal Number	ATIP-99-0097
Title	Ultra Low-Power Digital Correlator Detector for Microwave Polarimetry and Radiometry
PI	Piepmeier, Jeffrey

Abstract

This proposal is for an integrated digital correlation detector for passive microwave polarimetry (i.e., polarimetric radiometry). The central component of the detector module is an high-speed ultra-low power (ULP) digital correlator chip specifically designed for wide-band polarimetry. The module, however, is directly extensible to correlation detectors for synthetic thinned aperture radiometers (STAR) and spectrometers. Microwave polarimetry, STAR, and spectrometer technologies have been identified in the NASA/ESE Capability and Needs Assessment (CNA) matrix as necessary in order to enable the following ESE science themes and needs: ocean vector winds, cold hydrologic processes, soil moisture, sea salinity, and stratospheric chemistry. The target post-2002 notional mission for the polarimetry application is the new-technology demonstration radiometer on the ocean winds mission; the target operational mission is CMIS on NPOESS. Other target post-2002 missions for STAR and spectroscopy applications include soil moisture, sea surface salinity, and microwave limb sounder for startospheric chemistry.

The proposed digital detector is a two-channel complex correlation (I and Q) radiometer dectector module. The module development efforts will advance the state-of-the-art in microwave polarimetry and radiometry by processing hundreds-of-megahertz of IF bandwidth using a ULP high-speed CMOS integrated circuit and supporting components. The integrated circuit will be fabricated using the 0.35 _m ULP CMOS process available through the NASA Institute for Advanced Microelectronics at the University of New Mexico. The following steps will achieve technical progression from TRL 3 to TRL 5. First, a correlator circuit architecture design will be made, which will lead into the circuit design and layout. Fabrication of the IC using a state-of-the-art ultra low-power CMOS process and subsequent integration into a laboratory breadboard will advance the component to TRL 4. Integration of the IC into an IF detector module and demonstration using an existing radiometer will complete the progress to TRL 5.

Proposal Number	ATIP-99-0034
Title	A Ka-Band Active Array for Remote Sensing of Precipitation
PI	Sadowy, Gregory

Abstract

The Post-2002 Mission Workshop concluded that measurement of global precipitation had very high scientific value for the progress of earth system science. The current mission concept calls for a master satellite carrying a radar and passive sensors, augmented with several satellites equipped with passive sensors only. Because of ambiguities inherent in single frequency and polarization radar rain retrievals, a dual-frequency, dual-polarization radar can substantially improve retrieval accuracy. Recognizing these advantages, the Instrument Incubator Program has funded development of an innovative dual-frequency precipitation radar, ""Second Generation Precipitation Radar (PR-2)"". The antenna concept study conducted as part of that effort has identified key technologies that will need further development before implementation will be possible.

The key capabilities that set the PR-2 system concept apart from present and competing future systems are dual-frequency, dual-polarization operation and wide-swath scanning. These capabilities depend upon the development of a Ka-band electronically-scanned, dual-polarized, transmit and receive active array. The requirements of this array will push the limits of existing active array technology. Funding from ATIP for development of a scaled array prototype would give needed technology support to the IIP program and would both enhance the capabilities of and reduce required implementation time and risk for EOS-9:""Global Precipitation Mission"". Thus, this work, while primarily classified as an enabling technology (class 1), will provide benefits of risk and life cycle cost reduction (class 2).

We propose to develop a subarray that, except for length and number of elements, would be identical to the one required by the PR-2 radar system. The development program would encompass design and construction of transmit/receive (T/R) modules, feed horns, orthomode transducers (OMTs) and divider/combiner networks. These components would be integrated into an active array and the array□s performance measured. At the completion of the program, the performance of the modules and the array would be established and they would be ready for space qualification testing. When required to support EOS-9, the full-size space-qualified array could be built with greatly reduced cost and risk, on a shortened schedule. This development represents a technology advance from TRL 3 to TRL 5.

Proposal Number	ATIP-99-0092
Title	Efficient, Conductively-Cooled 2-Micron Laser Transmitter for Multiple Lidar Applications
PI	Singh, Upendra

Abstract

A technology development program leading to an efficient, conductively cooled, diode-pumped, double-pulsed 2-micron laser transmitter for atmospheric carbon dioxide (CO2) and global wind measurements is proposed. The need for global wind measurements has been recently endorsed by the Earth Sciences Enterprise (ESE), and is listed as ""OP-2 Tropospheric Wind Sounder"" in the Report of the Workshop on NASA ESE Post-2000 Mission. The need for the 2-micron laser transmitter technologies, such as proposed here, is specifically listed in record 66 of the ESE Capability/Need Matrix. On the other hand, ESE is also keenly interested in remote measurements of carbon dioxide from space. To fully understand the global atmospheric CO2 cycle requires measurements of atmospheric CO2 profiles on continental and global scales. Atmospheric modeling results to date suggest that a DIAL instrument operating around 2-micron wavelength offer real potential for making this important measurement in the future. To date, both of these measurements are not achievable, primarily because of the lack of laser transmitter technologies.

Since 1993, Langley Research Center (LaRC) has been engaged in research and development of a reliable, long-life, high-energy, efficient, all solid-state laser transmitter as an integral component of an eye-safe, Coherent Doppler Wind Lidar (CDWL) system for global atmospheric wind measurements. Development of a high-energy, high-efficiency DIAL at 2-microns is synergistic with LaRC□s 2-micron laser technology developments. LaRC has an investment of more than $5M in this technology and has developed and demonstrated a 125-mJ/6Hz diode-pumped 2-micron power oscillator and a 600 mJ solid-state liquid-cooled 2-micron laser transmitter in the laboratory. We propose to leverage the existing hardware, facilities, and expertise for the development of CO2 DIAL and coherent wind laser transmitter technology.

The goal of this proposal is to develop related technologies leading to a conductively-cooled, double-pulsed, diode-pumped 2-micron laser transmitter capable of generating in excess of 500 mJ at 10 Hz pulse repetition frequency (PRF) and improve the wall plug efficiency (WPE) to 5% from current state-of- the-art efficiency of less than 1%. To achieve that, 1) a fully conductively cooled laser head including the laser diode arrays will replace the liquid-cooled laser head. 2) Technology leading to double pulsing of the laser at 400 ?s, critical to DIAL measurement, will be developed. 3) To improve the wall plug efficiency, fully conductively cooled end-pump amplifier technologies will be developed. This laser transmitter can be used for wind as well as CO2 DIAL measurements.

Proposal Number	ATIP-99-0059
Title	Ultrahigh Dynamic Range, High-Speed A/D Converter for Laser Ranging
PI	Syage, Jack

Abstract

This NRA proposal builds on a very successful NASA SBIR project that demonstrated the feasibility of a component-level technology for extending the dynamic range of a high-speed analog-to-digital converter (ADC) by as much as several orders of magnitude compared to existing technology. The demonstrated technology combines a board-level transient digitizer with a proprietary algorithm for programmable signal processing that enables time-of-flight pulse counting mode simultaneous with detection of strong signal. A demonstration instrument has been validated in field tests with an atmospheric LIDAR and in the laboratory with a time-of-flight mass spectrometer. For NASA space- and air-borne requirements in LIDAR and laser range finding applications, this new technology can lead to more than an order of magnitude greater range without any other changes in hardware. For airborne remote sensing, the proposed technology provides greatly increased capability as well as enabling more compact design and a reduced cost. We propose a two-year program that enters at TRL 3 and exits at TRL 5. The technology directly supports several CNA focus areas and post-2002 national missions.

Proposal Number	ATIP-99-0095
Title	A 256 Baseline, 2-Bit Cross-Correlator Chip for a Spaceborne Synthetically Thinned Aperture Radiometer
PI	Timoc, Constantin

Abstract

Future synthetic aperture interferometric radiometers, such as thoseplanned for EOS-9 Global Precipitation Mission (GPM), will employ an instrumentconsisting of a thinned array of hundreds of miniaturized receivers anda massively parallel cross-correlator sub-system for digital signal processing. The objectives of Phase I are to develop, fabricate, and test a proof-of-designof a 16-baseline, 2-bit encoding, quadrature demodulation and cross-correlatorchip operating at clock frequency of 120 MHz to provide the critical designinformation for the development in Phase II of a radiation-hard, 256-baselinecorrelator chip and of an engineering model of a 9,216-baseline cross-correlatorsub-system dissipating less than 4.5 W. To achieve the stated objectives,the following synergistic combination of approaches will be used: a) innovativeexpandable architecture to enable the construction of cross-correlatorsub-systems with any number of antennas, b) new bit-systolic arrays foroperation at high frequency with low power consumption, c) novel radiation-harddigital circuit techniques, and d) advanced sub-micron CMOS fabricationtechnologies. The cross-correlator chip proposed in this project,if successfully realized, will enable the implementation of low-power cross-correlatorsub-systems for spaceborne synthetic aperture interferometric radiometersthat will be capable of performing high-sensitivity measurements of theEarth's environment.

Proposal Number	ATIP-99-0106
Title	Reprogrammable Data Path Processor
PI	Yeh, Pen-Shu

Abstract

The objectives of this proposed effort is to develop a general purpose Reprogrammable Data Path Processor (RDPP) Application Specific Integrated Circuit (ASIC) component that is applicable to multiple classes of scientific instruments requiring pre-processing of data on board. The requirements for this onboard processor is that it can process complicated scientific algorithms in real time at high speed with low power and with a goal of 48 GOPS per watt. It shall also be reconfigurable and can function in the space radiation environment.

The development approach is a three phase effort:

1. The first phase is to validate the architecture using algorithms specified by Earth Scientist such as FFT and convolution at the Goddard Space Flight Center (GSFC).

2. The second phase is to develop the flight qualifiable ASIC component using the radiation tolerant CMOS cell library developed by the Microelectronics Research Center (MRC) at the University of New Mexico (UNM). This phase will be joint effort between a contractor and the UNM with the ASIC being fabricated using a commercial foundry.

3. The third phase will demonstrate the RDPP ASIC component in a laboratory environment using scientist selected algorithms and data sets.

These three phases are executed in the six tasks described in the proposal. This proposed effort will raise the technology readiness level from 3 to 5.